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(54) Microstrip antennas.

(57) The invention relates to a microstrip antenna comprising a patch (32) of conductive material spaced from a ground plane by a substrate of dielectric material. The patch (32) comprises a first edge (F) connected electrically to the ground plane (8) and a further edge (G) arranged substantially parallel to the first edge (F) and a longer length than the first edge (F). In one embodiment a plurality, preferably four, patches (32) extend radially about a common point.

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COMMUNICATION

The European Patent Office herewith transmits as an enclosure the supplementary European search report under Article 157(2)(a) EPC for the above-mentioned European patent application.

If applicable, copies of the documents cited in the European search report are attached.

☑ Additional set(s) of copies of the documents cited in the European search report is (are) enclosed as well.

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The present invention relates to microstrip antennas.

Microstrip antennas may consist of a flat metallic patch separated from a ground plane by a relatively thin substrate of dielectric material. For the majority of applications the patches are designed to be resonant at a particular frequency. Many different shapes of patch have been proposed but the rectangular shape is the most commonly adopted. The lowest resonance, and hence maximum transmission frequency, occurs when the electrical length of the patch, which is equal to the physical length plus a small correction factor to account for fringing fields at the radiating edges, in one half the wavelength of the electrical energy propagating in the strip. Such antennas are commonly known, threfore, as half wave resonant structures.

For some applications, half wave resonant structures cannot be used in view of space constraints. A known technique for reducing the size of the resonant structure is to short circuit one of the edges of the patch to the ground plane. Resonance then takes place when the electrical length of the patch is approximately one quarter the wavelength of the propagating electrical energy, with radiation occurring from the edge of the patch opposite to the edge shorted to the ground plane. Such antennas are known as short circuited quarter wave resonant patches.

One application of the quarter wave resonant patch is in the four patch group, which may be used when circular polarisation of the transmitted radiation may be required. However, for many application the four patch group cannot be utilised in view of the space occupied by the group of rectangular patches.

The present invention seeks to alleviate the space problems of known microstrip antennas by the provision of an antenna having a patch of novel shape which, additionally, by variation of the respective lengths of certain sides of the patch provides enhanced antenna design flexibility.

Accordingly there is provided a microstrip antenna comprising a patch of conductive material spaced from a ground plane by a substrate of dielectric material, the patch comprising a first edge connected electrically to the ground plane and a further edge arranged substantially parallel to the first edge and of longer length than the first edge.

Preferably the patch is of isosceles or asymmetric trapezium shape.

The present invention also provides a microstrip antenna comprising a plurality of patches extending radially about a common point with the first edges thereof disposed about the common point. Advantageously there are four patches spaced from the ground plane.

In order that the invention may be clearly understood and carried readily into effect, embodiments thereof will now be described, by way of example only, with reference to the accompanying drawings in which:

Figures 1a and 1b show, respectively, schematic plan views of half wave and short circuited quarter wave resonant patch antennas;

Figures 2a and 2b show, respectively, schematic cross sectional views of the antennas illustrated in Figures 1a and 1b;

Figure 3 shows a schematic plan view of a four patch array incorporating the patch antenna illustrated in Figure 1b;

Figure 4 shows schematic plan views of resonant patch antennas in accordance with the present invention;

Figure 5 shows a schematic plan view of a four patch array incorporating patch antennas according to the present invention;

Figure 6 shows a graph of the resonant frequency of a patch antenna as illustrated in Figure 4, plotted against the length of the patch short circuited edge;

Figure 7 shows a graph of the resonant frequency of trapezium and rectangular shape patch antennas plotted against patch length; and

Figure 8 shows a graph of the resonant frequency of a trapezium shape patch antenna plotted against the width of the patch radiating edge.

Known forms of microstrip patch antennas are shown in Figures 1a and 1b. A rectangular shape patch 2 of conductive material is supported on a substrate 6 of suitable dielectric material which is provided with a metallic ground plane 8. The patch 2 is fed with a signal to be radiated via a connector 10 coupled to a feed point 12 by a pin 14 extending through the substrate 6. The feed point 12 is located so that the impedance of the patch 2 is substantially matched to that of the connector 10.

In the antenna shown in Figures 1a and 2a the lowest resonance occurs when the electrical length L_R of the patch 2, which is equal to the physical length plus a small correction factor to account for fringing fields at the radiating edges, is one half the wavelength of the energy propagating in the transmission line formed by the patch, with radiation of the signal taking place from the edges A and B.

One of the edges D of the patch 2 can be short circuited to the ground plane 8, such as by a number of conducting pins 16, as shown in Figures 1b and 2b. Resonance then occurs when the electrical length of the patch is approximately one quarter the wavelength of the propagating electrical energy, with radiation taking place from the edge E opposite the grounded edge D. Such short circuited antennas find particular application in the four patch circularly polarised array, as shown in Figure 3. Each patch 18 to 24 is linearly polarised by a feed network (not shown) which is arranged to introduce a progressive 90 degree phase shift between the patches of the array so

that the four patch group as a whole exhibits circular polarisation of the radiated signals. However, for many practical applications space limitations preclude the use of quarter wave patches of rectangular shape.

It can be appreciated, therefore, that many applications exist for resonant patch antennas with even smaller area than the short circuited quarter wave patch. It has been realised with the present invention that one patch shape which meets this requirement is a trapezium shape 26 with one short circuited edge F as shown in Figure 4. When fed with a signal via the feed point 12, linearly polarised radiation occurs from the edge G opposite to the short circuited edge F. The trapezium shape may be the isosceles trapezium 26, having axial symmetry, or assymetric trapezium shapes which exhibit similar radiation characteristics, such as a right angled trapezium 28 or a general trapezium 30, as shown in Figure 4.

The short circuited trapezium patch 26 has several advantages over the short circuited rectangular patch in addition to it occupying a smaller area whilst resonating at the same frequency. The trapezium shape is well suited to forming a multipatch array, such as the four patch array 32 shown in Figure 4. The "Maltese Cross" array 32 shown in Figure 4 resonates at the same resonant frequency as the array shown in Figure 3 but occupies substantially less area; for the example shown, approximately 65% of the area of the rectangular patch array. The array 32 may be fed with a progressive phase shift in the same manner as described above with reference to Figure 3 to provide the circular polarisation of the radiated signals.

Furthermore, in view of the truncated triangular format of the trapezium patch 26, it can be seen from a comparison between Figures 3 and 5 that the radiating edge G of the trapezium patch, can be made long in comparison to the rectangular patch radiating edge E, thereby increasing the directive gain of the antenna, whilst the earthed edge F of the trapezium shape patch can be made relatively short in comparison to the rectangular patch earthed edge D, thus requiring fewer short circuit pins 16.

Moreover, the flexibility of the trapezium shape, as illustrated by the shape variations shown in Figure 4, means that three further variables, namely the relative lengths S and W of, respectively, the short circuited edge and the radiating edge, and the height L of the trapezium are available to the antenna designer to enable, for example, a most compact array or a transmission characteristic, to be achieved.

Figures 6 to 8 illustrate how the resonant frequency of the trapezium shape varies with a change in the physical dimensions L, S and W, of the patches. The results shown in Figures 6 to 8 were derived for a series of patches formed on a 12.7mm thick, low permittivity foam substrate, normalised dimensions and frequencies being used in these figures.

The effect on the resonant frequency of varying the length S of the short circuited edge F of the trapezium shape is shown by the broken line plot in Figure 6. It can be seen that maximum reduction in resonant frequency is achieved when the length L is zero i.e. the trapezium becomes a triangle.

Figure 6 also shows, in solid line, the theoretical relationship between the resonant frequency and the length L_R of a short circuited rectangular patch formed on a similar low permittivity foam substrate.

The plots shown in Figure 6 illustrate, therefore, the savings in area which can be achieved by using the trapezium shape patch instead of rectangular shaped patch.

Figure 7 shows, in broken line, the effect on the resonant frequency of varying the length L of a typical trapezium shape patch, together with the same variation for the rectangular shape patch shown by the solid line plot. It can be seen from Figure 7 that for a given resonant frequency, the trapezium shape patch is far shorter than the rectangular shape patch.

Figure 8 shows that the resonant frequency can be controlled by controlling the width W of the radiating edge of the trapezium. By contrast, it is known that the resonant frequency of the rectangular shape patch is independent of width.

Therefore, it can be seen from Figures 6 to 8 that the trapezium patch not only provides substantial savings in area, in comparison to rectangular shape patches, but also provides increased flexibility to the antenna designer as the resonant frequency is dependant not only upon the patch length but also the lengths of the grounded and radiating edges.

Although the present invention has been described with respect to a specific embodiment it should be understood that modifications may be effected whilst remaining within the scope of the invention. For example, the patch array need not necessarily comprise four patches. Furthermore, the side edges ie: non radiating and non grounded edges of the patch may not necessarily comprise single linear edges. The side edges may be slightly curved or may also comprise a number of edges having a slight offset with respect to each other and arranged to maintain a substantially trapezium shape. Furthermore, the antenna can be constructed in a pure planar manner or as a single or double curved surface such as, for example, a vehicle roof.

Claims

1. A microstrip antenna comprising a patch of conductive material spaced from a ground plane (8) by a substrate of dielectric material, characterized in that said patch (26, 28, 30, 32) comprises a first edge (F) connected electrically to the ground plane (8) and a further edge (G) arranged

substantially parallel to the first edge (F) and of longer length than the first edge (F).

2. A microstrip antenna as claimed in Claim 1, characterized in that said patch (26) has an isosceles trapezium shape.

3. A microstrip antenna as claimed in Claim 1, characterized in that said patch (28) has an asymmetric trapezium shape.

4. A microstrip antenna as claimed in any one of Claims 1 to 3, characterized in that the antenna comprises a plurality of said patches (32) extending radially about a common point.

5. A microstrip antenna as claimed in Claim 4, characterized in that there are provided four patches (32) disposed about the common point.

6. A microstrip antenna as claimed in any one of Claims 1 to 5, characterized in that at least one of the side edges of the patch is curved.

7. A microstrip antenna as claimed in any one of Claims 1 to 6, characterized in that said antenna is substantially planar.

8. A microstrip antenna as claimed in any one of Claims 1 to 7, characterized in that said antenna defines a curved surface.

9. A vehicle having at least part of its body formed as an antenna as claimed in any one of Claims 1 to 8.

10. A vehicle having at least part of its roof formed as an antenna as claimed in any one of claims 1 to 8.

Fig.1a.

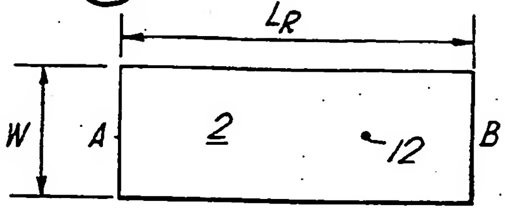


Fig.1b.

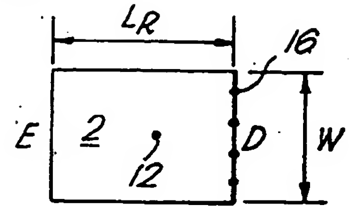
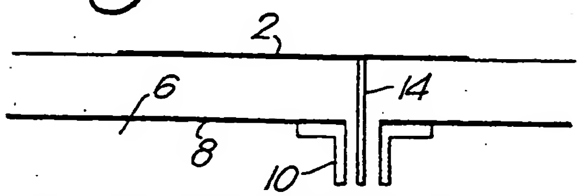
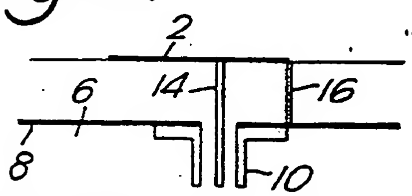


Fig.2a.



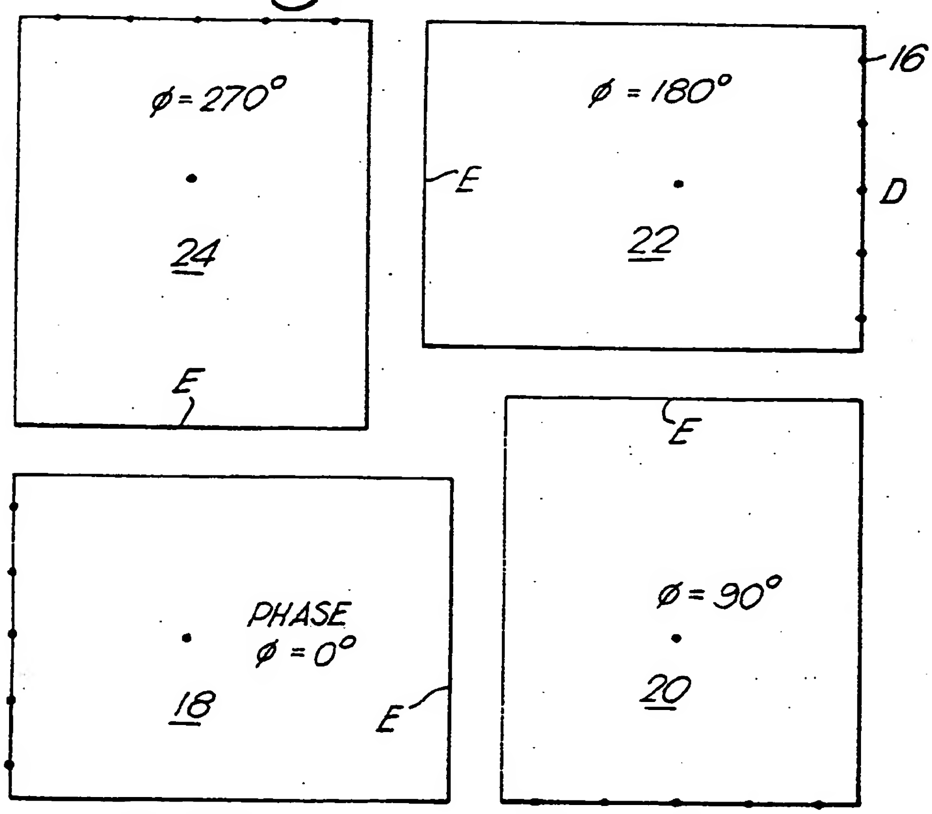
(a) HALF-WAVE RESONANT PATCH.

Fig.2b.



(b) SHORT-CIRCUITED QUARTER-WAVE RESONANT PATCH.

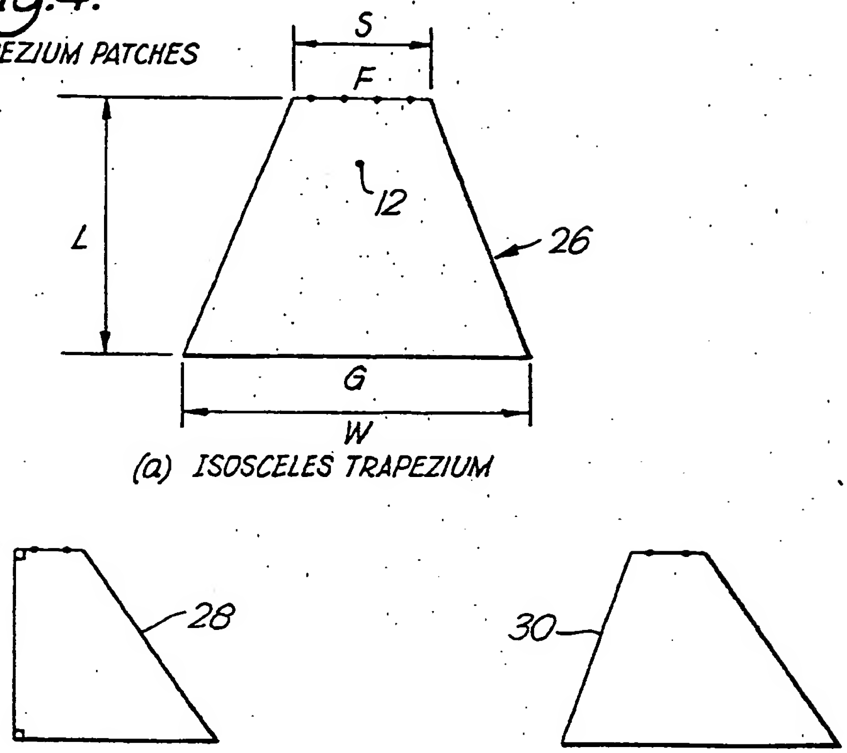
Fig.3.



FOUR-PATCH CIRCULARLY POLARISED ARRAY.

Fig.4.

TRAPEZIUM PATCHES

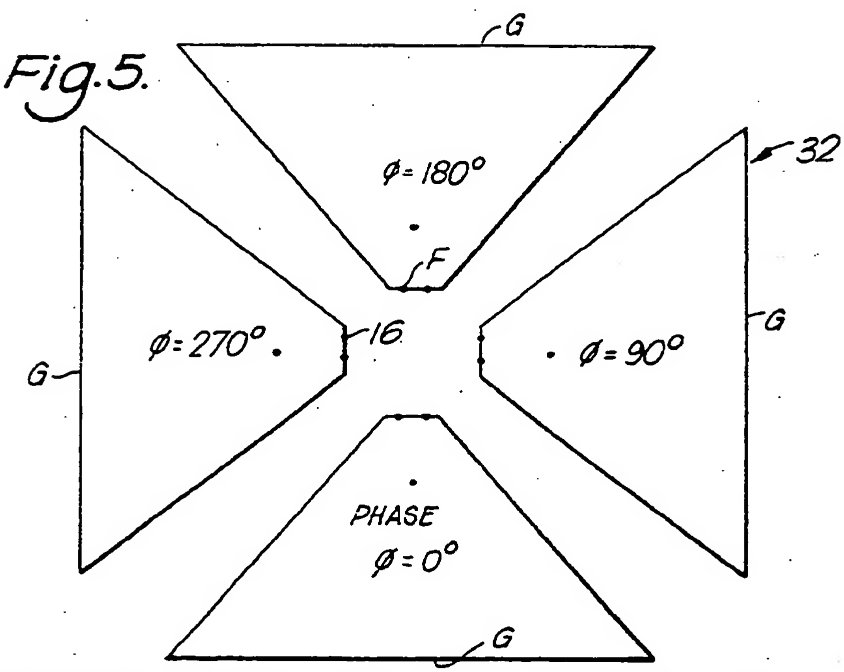


(a) ISOSCELES TRAPEZIUM

(b) RIGHT-ANGLED TRAPEZIUM

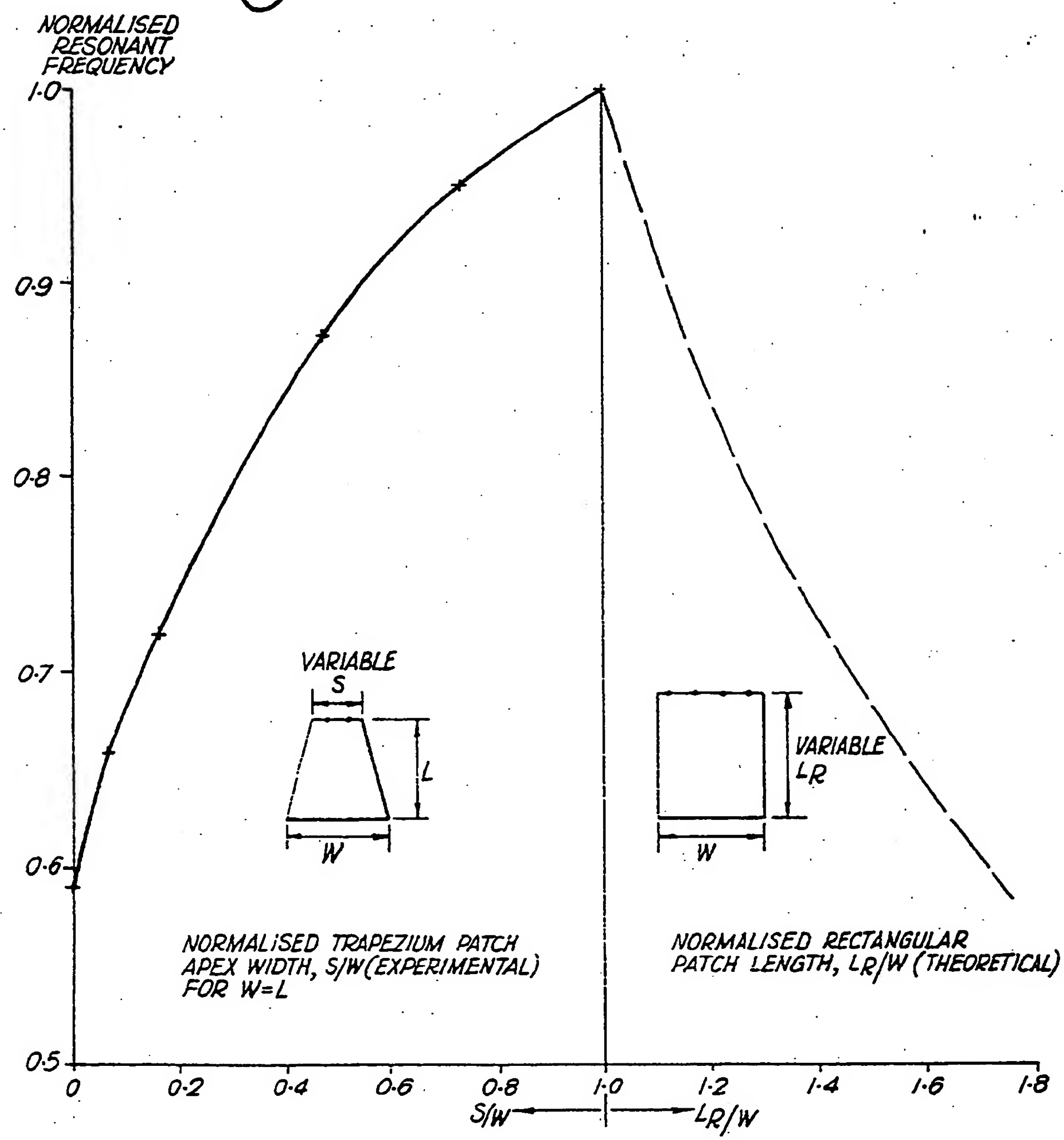
(C) GENERAL TRAPEZIUM

Fig.5.



CIRCULARLY POLARISED FOUR-ELEMENT TRAPEZIUM ARRAY.

Fig.6.


NORMALISED RESONANT FREQUENCY
1·0
0·9
0·8
0·7
0·6
0·5
0
0·2
0·4
0·6
0·8
1·0
1·2
1·4
1·6
1·8
S/W
LR/W
VARIABLE
S
L
W
VARIABLE
LR
W
NORMALISED TRAPEZIUM PATCH APEX WIDTH, S/W(EXPERIMENTAL) FOR W=L
NORMALISED RECTANGULAR PATCH LENGTH, LR/W (THEORETICAL)

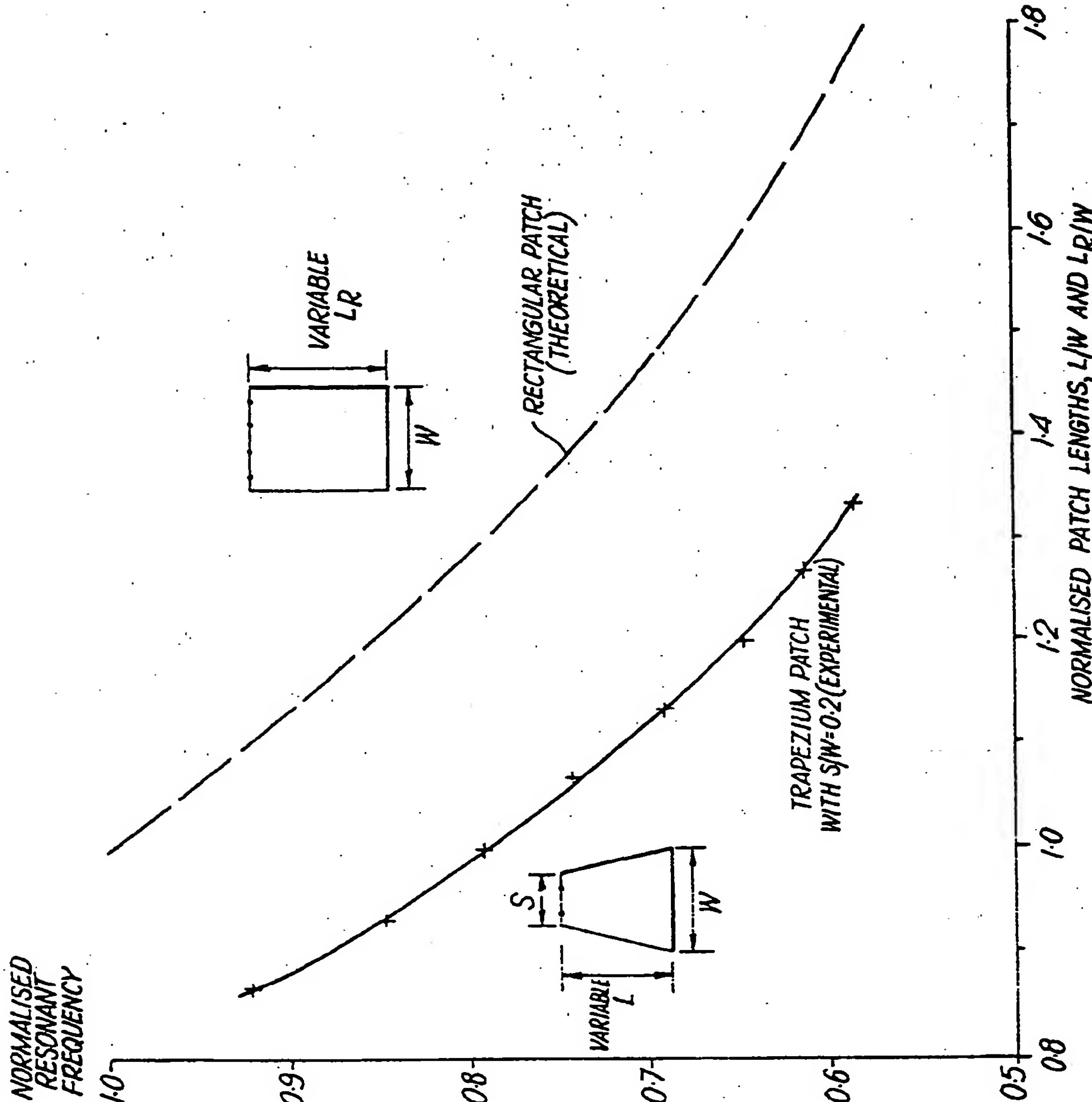
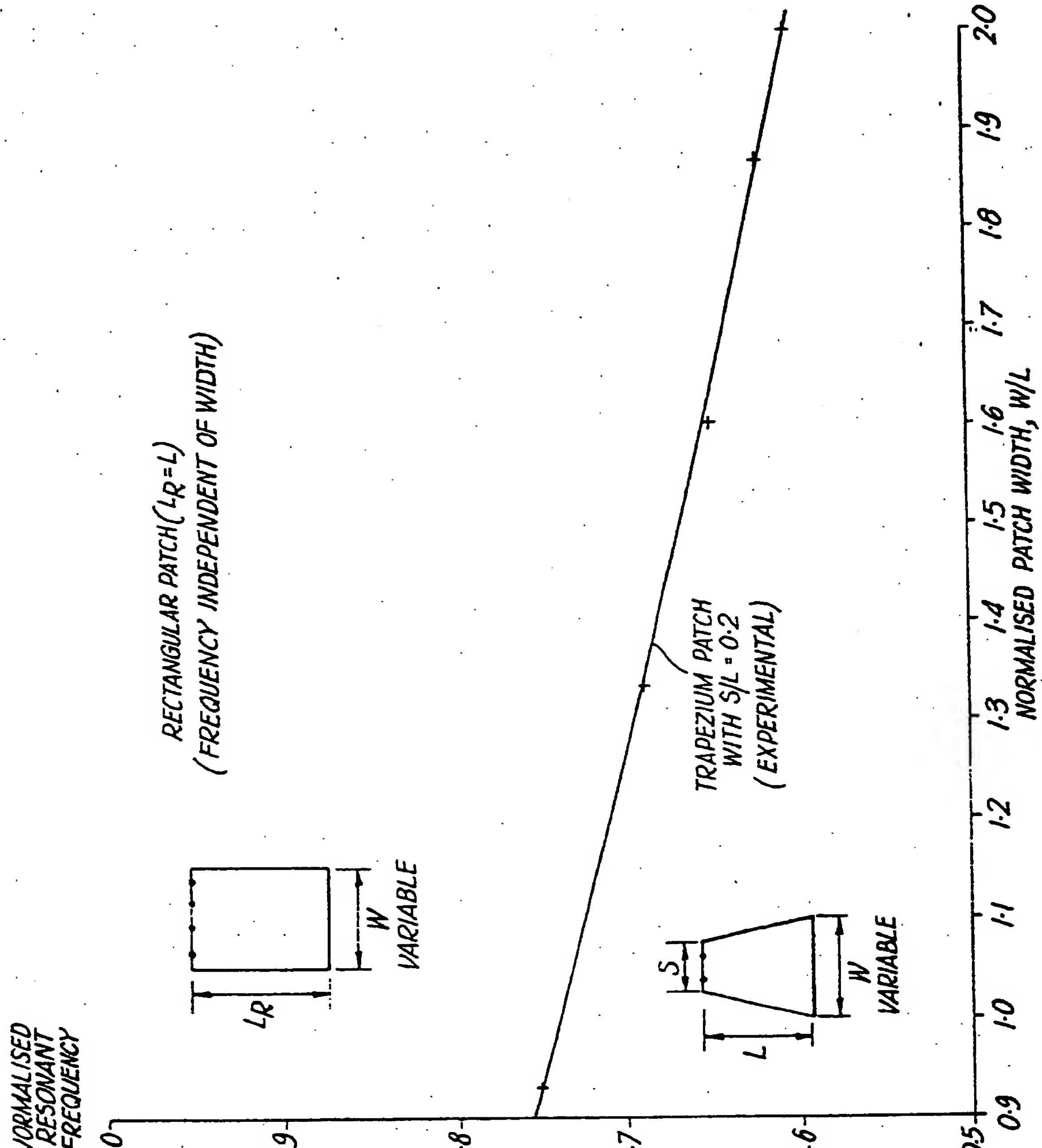

NORMALISED RESONANT FREQUENCY
1·0
0·9
0·8
0·7
0·6
0·5
0·8
1·0
1·2
1·4
1·6
1·8
NORMALISED PATCH LENGTHS, L/W AND LR/W
RECTANGULAR PATCH (THEORETICAL)
TRAPEZIUM PATCH WITH S/W=0·2 (EXPERIMENTAL)
VARIABLE LR
W
S
W
VARIABLE L

Fig.7.

Fig.8.


NORMALISED RESONANT FREQUENCY
1·0
0·9
0·8
0·7
0·6
0·5
0·9
1·0
1·1
1·2
1·3
1·4
1·5
1·6
1·7
1·8
1·9
2·0
NORMALISED PATCH WIDTH, W/L
RECTANGULAR PATCH (L_R=L)
(FREQUENCY INDEPENDENT OF WIDTH)
L_R
W
VARIABLE
TRAPEZIUM PATCH
WITH S/L = 0·2
(EXPERIMENTAL)
S
L
W
VARIABLE